SECOND SUBJECT—POST-GRADUATE COURSES AND SPECIAL QUALIFICATIONS.

Make a complete statement of any post-graduate course you have pursued or work you have done. State particularly any special qualifications you possess which in any way fit you for the duties of scientific aid and the special work you desire to take up.

THIRD SUBJECT—THESIS OR OTHER LITERATURE.

Submit a thesis of not less than 2,000 words on any scientific subject, or, in lieu thereof, any other literature or publications on scientific subjects which you have prepared.

JURAT.

(The following oath must be taken before a notary public or other officer authorized to administer oaths for general purposes, and the officer's signature must be authenticated by official seal. If the oath be taken before a justice of the peace or other officer who has no official seal, his official character must be certified by the clerk of the court, secretary of state, or other proper officer, under official seal.)

I, the undersigned, do solemnly swear (or affirm) that in the preparation of the accompanying thesis, or other literature required under subject three, the composition is entirely my own, and that I have given full credit, by quotation marks or references, to authorities for any quoted matter.

(*Signature of competitor*:) ——— ———.

Subscribed and sworn to before me by the above-named applicant, to me personally known, this ——— day of ———, 189–, at ———, county of ———, and State [or Territory or District] of ———.

(*Signature of officer*: ——— ———.

[OFFICIAL SEAL.] (*Official title*:) ——— ———.

The official seal must not be omitted.

RECORDS BY THE MILNE SEISMOGRAPH.

On Plates V and VI we have reproduced a number of facsimiles of the records made by the Milne seismographs that are established and kept in working order by the Canadian Meteorological Service at its stations in Toronto and Victoria, B. C. It is very much to be hoped that similar apparatus will be established at a few places in the United States for the purpose of tracing the progress of the undulations that run around the whole globe whenever an earthquake of any importance occurs. If it were desired to investigate the phenomena of the smaller local earthquakes an instrument of different pattern and more numerous stations would be required. Studies of this local nature have been already undertaken in many countries, but the establishment of the Milne apparatus, which is now set up at about twenty stations, is in accordance with an international scheme which looks to the study of the exceedingly minute oscillations that extend to great distances from any center. Both the general and the local disturbances must be studied in order to prepare the way for any system of forecasting earthquakes, or the erection of earthquake-proof buildings and monuments. There can be no doubt but that seismic disturbances originate in a variety of ways and have a corresponding variety of phenomena. When an eruption is about to occur from a volcano there are short severe shocks in rapid succesion, comparatively near the surface and not liable to be felt many miles away. When the general geological strata are strained and eventually crack, and slide over each other, a slower dislocation, or so-called fault, is produced. This involves the movement of a large mass, oftentimes at considerable depths in the earth, and the disturbance or wave of shock may be felt for several hundred miles, while a gentler wave or oscillation may run entirely around the globe, and, perhaps, even several times around. When such a wave passes a distant station, it simply produces at the surface of the ground a slight undulatory movement, although far beneath the surface the movement may be one of compression and rarefaction. The Milne seismograph is adapted to record this gentle undulation or tremor, by which the surface and all objects standing upon it are slowly tipped forward and backward as the successive waves pass by the spot, for it generally happens that a single wave can not travel alone, but is preceded and followed by smaller waves, so that the whole series forms a group. Our diagrams show such groups of waves on January 24, April 16, June 4, 5, and June 14, all in the present year.

The apparatus with which these records are made is called the horizontal pendulum seismograph. It was invented by Prof. John Milne, and general descriptions of its construction, as well as of the work done by the British Association for the Advancement of Science, through its various committees on seismological observations, are given in successive annual reports of the Association, especially those for 1896–97–98. Some idea of the apparatus is given by fig. 1, in which we see that when the horizontal beam, technically called a boom, which is made exceedingly light and is about 30 inches long, remains stationary, then the light of the lamp reflected downward from the mirror is photographed upon a strip of paper that is moving slowly along below it. This is the central black line shown on Plates V and VI. If the supporting stand is disturbed, the longer end of the boom oscillates horizontally like a pendulum, producing the broadenings of this line. The boom gradually comes to rest and so remains until another disturbance occurs, and the line again broadens. Our illustrations show that the shocks come sometimes in such rapid succession that the boom has no chance to come to complete rest between each shock; thus an earth tremor can usually be analyzed into a series of increasing and decreasing oscillations.

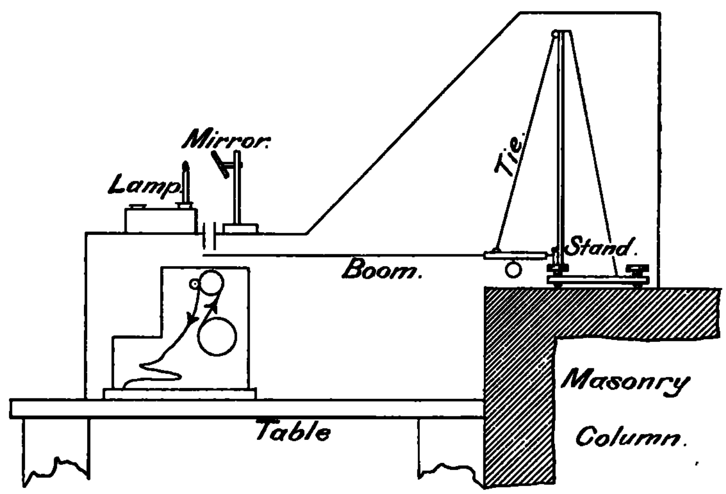

FIG. 1.—Milne horizontal pendulum seismograph.

When the Milne apparatus is first set up there is apt to be need of adjustment almost daily, owing to the fact that the masonry column and the soil beneath it is undergoing a slight progressive change. It takes a long time for a newly built column to come into a permanent quiescent state. Again, there are many localities in which the geological strata are apparently undergoing a slow progressive deviation from horizontality. Mr. Milne mentions such in the Isle of Wight, where the shocks are too local in their character to be called earthquakes. Mr. G. K. Gilbert, of the United States Geological Survey, has argued with some plausibility that the whole region of the Great Lakes is being slowly canted toward the south-southwest (see MONTHLY WEATHER REVIEW, April, 1898, p. 164), at a rate which he expresses in inches, for a base line of 100 miles, but which may also be expressed in angular measurement, and is equivalent to a rate of 0.15 seconds of arc in a hundred years at the slowest, and 0.50 seconds at the fastest. Even this exceedingly slow movement could be made appreciable to a Milne seismograph, which is ordinarily so adjusted that half a second of arc corresponds to a movement at the end of the boom of one-twenty-fifth of an inch, and it can easily be made more sensitive. This instrument is not sensitive to sudden, quick shocks transmitting short elastic vibrations that are not in harmony with the natural time of vibration of the boom itself. Thus the blasting of powder, the heavy rumbling of wagons, the firing of artillery have little or no effect in producing a swing of the boom. The ordinary time of oscillation for a light boom is about one and one-half minutes; but for a heavy boom it may be five minutes before it comes to rest. Our illustrations show many cases in which the boom did not come to rest before a new oscillation began. The time required for it to come to rest in the Toronto instrument is apparently a little longer than the case of the Victoria apparatus.

Professor Milne remarks that inasmuch as ordinary pendulums, chemical balances, and magnetometers show appreciable motions going on (although shut up within a box to protect them from draughts of air) so, in the case of the horizontal pendulum, motions may be caused by currents of air within the box which are not due to the tremors of the pier or ground. Many movements of the boom have been traced back to the changes in atmospheric moisture, pressure, and temperature even in the steady climate of England. In general, the air currents within the boxes and the movements in the superficial soil adjoining the building and the pressure of high winds against the walls of the observatory produce movements in the boom that are not due to seismic tremors. Every instrument has to be studied with reference to annual and diurnal changes in the meteorological influences. Professor Stupart states that at Toronto the seismograph was, from September, 1897, to December, 1898, placed on a heavy stone pier set 8 feet in the ground in a wooden frame outbuilding a few yards from the Astronomical Observatory.

In years gone by this pier had been used for magnetic observations; it was found, however, that the boom was much affected by air currents in calm radiation weather, and after trying many and various experiments to get rid of these, I decided to remove the instrument to the old magnetic cellar in the observatory which had been left vacant when the new magnetic observatory was built nine miles from Toronto; since the change we have had no trouble and our earth tremors are beautifully defined. In Victoria I placed the instrument on a cement pier built on the solid rock within a few yards of tide water, in the basement of an old Government building, and we have not been troubled with air currents at all.

The seismograph at Toronto was constructed by Robert W. Munro, Granville Works, Granville Place, Kings Cross Road, London, England, and cost $265 to which must be added about $35 for installation. If a suitable building had to be constructed the cost would of course be much greater.

Besides the disturbances produced by the atmosphere, this delicate horizontal pendulum frequently shows sudden jumps which in the observatory at Tokio were always toward the east for the first nine months, followed by three months of westerly motions, then three months of easterly, and then three months of erratic movements. Possibly, these all indicate a creeping of the soil for a long time in one direction and then in another. The total change during nearly two years was equivalent to a tip of the west side upward to the amount of seventeen seconds. Different forms of earthquake apparatus have been described by Milne, Gerland, and others, each of which records some special kind of movement, so that, in general, if instruments of several descriptions could be installed at the same locality, we might add to our records of earthquakes other forms of motion additional to those that are recorded by horizontal pendulums. Mr. C. G. Knott says that besides the daily and annual solar periods in earthquake frequency, there are daily, fortnightly, and monthly lunar periods, and in some cases, half daily periods. The idea is that the tidal stresses, due to the attraction of the moon for the solid earth, must produce these disturbances.

The first instrument of the Gray-Milne pattern was set up in 1883, at the central observatory in Tokio, where Prof. Thomas Gray, now of Terre Haute, and Prof. John Milne, now of Shide Hill House, Newport, on the Isle of Wight, were at that time associated together. This first seismograph still continues in use, and has recorded about 2,000 quakes, which are printed in full in the Reports of the British Association for the Advancement of Science.

In the report for 1897, Mr. Milne gives many details as to the construction and behavior of the apparatus at about ten stations and abstracts of the results. Among other things, he shows that many times the ocean cables are broken by earthquake shocks and not by anything inherent in the cable. The average number of breaks is about twenty-three per year for the 10,000 miles of cable that are at present in active use.

As a curious illustration of the possible value of a system of seismographic records, Milne alludes to the fact that in 1888 the two cables connecting Java and Australia were simultaneously broken and Australia cut off from the outside world for nineteen days; not knowing but that war had broken out, the military and naval reserves were called out to meet any possible contingency. In 1890 three cables were simultaneously broken and Australia was cut off for nine days. On both of these occasions a few seismographs would have sufficed to show the cause of the interruption and would have allayed the fear of war and the accompanying commercial paralysis. Milne's apparatus at Shide shows a record for every earthquake in Japan and the absence of record may be taken to mean the absence of an earthquake; thus, in September, 1896, when the English newspapers announced a great earthquake in Kobe, and those who had friends in Japan were filled with anxiety, Milne's record showed that no great earthquake could have occurred, and it was subsequently found that the cablegram was devoid of all foundation.

It is hoped that the accurate study of earthquakes will show whether the shocks go through the earth or around it, and thus give us some idea of the structure of the interior of our planet.

In the report of the British Association for the Advancement of Science for 1898, Professor Milne gives a list of twenty stations already supplied with his apparatus, and of ten or twelve more that have the matter under consideration. The work thus initiated by his committee is rapidly assuming the character of international cooperation, in which Great Britain and her colonies are taking the most prominent part.

On November 29, 1896, there was an extraordinary rainstorm on the island of Montserrat in the West Indies, which comes under the governor of the Leeward Islands; 20 inches of rain fell in the center of the island in about twelve hours, and since that time, it has been subject to constantly recurring slight shocks of earthquake, which come almost every day but do little harm. The rainstorm is supposed "to have set the earthquakes going," and the sulphur springs now emit much more gas than formerly. The sulphur springs and hot water springs are supposed to be connected with the crater of some extinct volcano. It is said that in 1880, there was a similar flood in the neighboring island of St. Kitts, and that simultaneously with that there occurred a volcanic disturbance in Dominica.

In order that records kept in all parts of the world may be compared and discussed, it is necessary that there should be some agreement as to the standard of time employed, and to this end a table showing the civil time employed at many places throughout the world is being prepared by Mr. Milne. The earthquake observatories and apparatus at six stations in Italy and Germany are described by him in the British report for 1898. A seismological institute is now established at the University at Strasburg under the superintendence of Dr. G. Gerland.

The style of record given by the Milne seismograph is abundantly illustrated on Plates V and VI, which contains records of the following earthquakes:

1. January 24–25, 1899. This was the great earthquake at the City of Mexico. This severe shock was not appreciable to any of the Weather Bureau observers, but it made well-marked records on the seismographs at Toronto and Victoria. It reached Toronto at 23:50:24, Greenwich civil time, and attained its maximum at 0:19:55 of the 25th. The corresponding times for Victoria were 23:51:7 p. m. of the 24th and 0:2:54, Greenwich civil time, 25th. At the Isle of Wight the shock arrived at 0:24:42, Greenwich civil time, of the 25th, according to a letter from Mr. Stupart.

2. April 16. This disturbance began at Toronto 13:48:59, Greenwich civil time, April 16; maximum, 14:2:48; ended, 15:22:10. At Victoria the disturbance began at 13:42:30, Greenwich civil time, and ended at 15:33:42. This tremor was apparently of Japanese origin, according to Mr. Stupart.

3. June 5. Toronto: began June 5, 4:42:27, Greenwich civil time; maximum, 4:54:16; ended, 7:3:51. Victoria, began June 5, 4:48:10, Greenwich civil time; maximum, 5:9:0; end, 6:46:1. This tremor may have been of West Indian origin, according to Mr. Stupart; it occurred at the close of June 4, local reckoning, at Toronto and Victoria, but early on June 5, by Greenwich time.

4. June 5. Toronto: began, 15:7:54; maximum, 15:16:0; end, 17:17:?. Victoria: began, 15:13:1; maximum, 15:30:47; end, 16:12:43.

5. June 14. Toronto: began, 11:13:48; maximum, 11:23:0; ended, 13:18:57. Victoria: began, 11:17:25; maximum, 11:57:32; ended, 13:37:42.

THE WEATHER OF THE MONTH.

By ALFRED J. HENRY, Chief of Division of Records and Meteorological Data.

There was a very marked fall in pressure from April to May, 1899, over practically the whole of the United States, the monthly mean for the central and southern Rocky Mountains, the eastern foothills, and the plains being from .05 to .12 inch lower than during the preceding month. As the fall in pressure was greatest in the central Rocky Mountain region and least on the coasts, the chart of monthly distribution, No. IV, naturally shows a marked depression central in Colorado, with rather strong gradients in all directions, except to the southward. The chart of monthly pressure distribution is, in fact, an excellent type of certain winter lows that strike the continent about midway of the California coast and pass across the country from ocean to ocean. The weather of the month was not greatly unlike what is generally experienced with a similar distribution of pressure for a single day. To the northward of the region of lowest pressure it was cold, wet, and generally disagreeable. In the Gulf, South Atlantic, Middle Atlantic, and New England States warm and generally dry weather prevailed, while heavy rains were experienced in the panhandle of Texas, Oklahoma, and generally northeastward of Colorado. About the usual number of cloud bursts, destructive hailstorms, severe local storms, and tornadoes were reported. The electrical storms of the month were rather more numerous and violent than usual.

TEMPERATURE OF THE AIR.

The weather continued cool and unseasonable in the Northwest, this being the fourth consecutive month with temperature decidedly below normal. The greatest departure from normal conditions was in Montana, in which State there was an accumulated deficiency in temperature since January 1 of 1,184°, or an average of nearly 8° per day. The snowfall in Montana, western Wyoming, and eastern Idaho was unusually heavy, as may be seen by reference to Chart VIII. Minimum temperatures as low as 3° in Colorado and 7° in Montana were observed at single stations. The temperature was relatively low on the Pacific coast and generally throughout the Plateau region. Southward and eastward from central Colorado temperature was above normal, the regions of greatest excess being the Gulf States and the Ohio Valley and Tennessee.

In Canada.—Professor Stupart says:

The mean temperature of May was from 2° to 6° below average in Manitoba, the Northwest Territories and British Columbia, and a little above average in Ontario, Quebec, and the larger portion of the Maritime Provinces. Stations in southern Alberta show the greatest departure below, and those in central Ontario the greatest departure above average. The weather of the Northwest Territories was marked by two cold spells, the first of which occurred during the first few days of the month, when the temperature fell to 12° at Calgary, 10° at Edmonton, and 21° at Qu'Appelle; and the second during the 12th and few following days, when 14° was recorded at Calgary, 15° at Edmonton, and 21° at Prince Albert and Winnipeg. This latter cold spell spread rapidly eastward across the Dominion, and was pronounced in Ontario from the 14th up to about the 21st. The last heavy frost occurred in the Northwest and Manitoba about the 19th.

Average temperatures and departures from the normal.

Districts.	Number of stations.	Average temperatures for the current month.	Departures for the current month.	Accumulated departures since January 1.	Average departures since January 1.
		°	°	°	°
New England	10	54.1	+ 0.2	− 1.1	− 0.2
Middle Atlantic	12	62.4	+ 0.9	− 3.8	− 0.8
South Atlantic	10	72.4	+ 2.1	− 3.3	− 0.7
Florida Peninsula	7	78.5	+ 2.7	+ 0.4	+ 0.1
East Gulf	7	76.9	+ 4.3	− 6.7	− 1.3
West Gulf	7	76.5	+ 3.9	− 6.3	− 1.3
Ohio Valley and Tennessee	12	68.5	+ 3.4	− 5.7	− 1.1
Lower Lake	8	58.5	+ 1.7	+ 0.1	0.0
Upper Lake	9	53.5	+ 2.1	− 6.0	− 1.2
North Dakota	7	51.7	− 1.8	−17.5	− 3.5
Upper Mississippi	11	63.1	+ 1.6	−10.4	− 2.1
Missouri Valley	10	62.6	+ 2.1	−12.6	− 2.5
Northern Slope	7	50.9	− 2.5	−23.2	− 4.6
Middle Slope	6	64.7	+ 2.6	−11.0	− 2.2
Southern Slope	6	70.5	+ 1.8	+ 1.2	+ 0.2
Southern Plateau	13	62.4	− 4.5	− 3.4	− 0.7
Middle Plateau	9	51.7	− 5.0	− 8.7	− 1.7
Northern Plateau	10	49.7	− 5.9	− 9.8	− 2.0
North Pacific	9	49.5	− 4.7	− 8.6	− 1.7
Middle Pacific	5	54.9	− 3.5	− 1.3	− 0.3
South Pacific	4	58.6	− 3.8	− 1.7	− 0.3

PRECIPITATION.

The area over which rain was in excess of the normal is probably a little less than the area over which rainfall was below the normal amount. Considered by districts, the minus departures are greater than the positive departures as 2 to 1. The districts having the greatest negative departures are the east Gulf, 2.8 inches; Florida peninsula, 2.9; New England, 1.8. The districts having the greatest positive departures are upper Mississippi valley, 2.5; North Dakota, 1.1; southern Slope, 1.2; northern Slope, and north Pacific, 1.1, respectively.

On the whole the month should be classed as one of about

Records Made by Milne Seismograph.

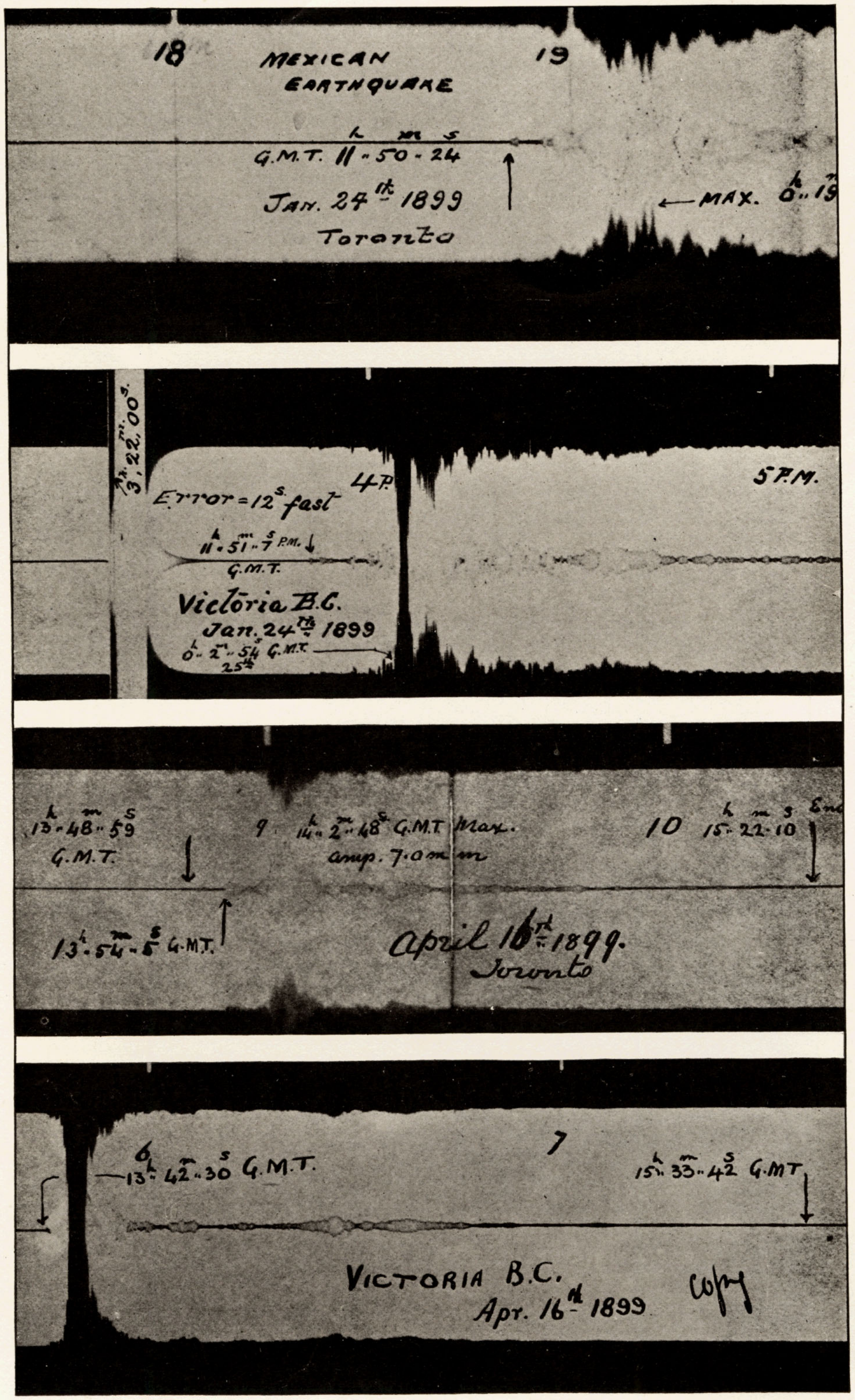

Plate VI. Records Made by Milne Seismograph.